

WHAT IS CLAIMED IS

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1. A multi-level data processing method for converting a binary data into a multi-level data having  $n$  bits per symbol, where  $n$  is an integer satisfying  $n \geq 2$ , comprising:

10       arranging a  $\{(n - 1) \times m\}$ -bit binary data in upper  $(n - 1)$  bits of multi-level data of  $m$  symbols, where  $m$  is an integer satisfying  $m \geq 2$ ; and

          converting a  $(m - k)$ -bit binary data into  $m$  bits according to a predetermined conversion rule and  
15       arranging the  $m$  bits in a lower 1 bit of the multi-level data of  $m$  symbols, where  $k$  is an integer satisfying  $m > k \geq 1$ , so as to convert a  $(n \times m - k)$ -bit binary data into 1 set of multi-level data made up of  $m$  symbols.

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2. The multi-level data processing method as claimed in claim 1, wherein  $k = 2$ .

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3. The multi-level data processing method as claimed in claim 1, further comprising:

relating data within other sets to the  $m$  bits when converting the  $(m - k)$ -bit binary data into the  $m$  bits.

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4. The multi-level data processing method as claimed in claim 1, further comprising:

mixing to the multi-level data made up of the  $m$  symbols a test data which includes  $2^{(M \times n)}$  combinations of  $M$  consecutive multi-level data, where  $M$  is an integer satisfying  $M \geq 3$ .

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5. The multi-level data processing method as claimed in claim 4, which reproduces multi-level data from a reproduced signal which is reproduced from an information recording medium which is recorded with a mixture of the multi-level data amounting to the  $m$  bits and the test data, comprising:

25 inputting the reproduced signal of the test data

and storing signal values of the multi-level data;

inputting the reproduced signal of the multi-level data which has been converted from the binary data;

calculating errors between the signal values of the  
5 multi-level data and the stored signal values;

outputting a multi-level data having a smallest error as a judging candidate of each symbol within one set as a first candidate, and outputting a multi-level data having a second smallest error as a second  
10 candidate;

generating a candidate of a multi-level data series of m symbols within one set according to the predetermined conversion rule, using the first and second candidates for each symbol;

15 calculating errors between the signal value of each symbol and stored signal values corresponding to the candidate multi-level data; and

outputting as a reproduced multi-level data a multi-level data series having a smallest total of the  
20 errors amounting to m symbols of one candidate.

25 6. A multi-level data processing apparatus

for converting a binary data into a multi-level data having  $n$  bits per symbol, where  $n$  is an integer satisfying  $n \geq 2$ , comprising:

means for arranging a  $\{(n - 1) \times m\}$ -bit binary data  
5 in upper  $(n - 1)$  bits of multi-level data of  $m$  symbols, where  $m$  is an integer satisfying  $m \geq 2$ ; and

means for converting a  $(m - k)$ -bit binary data into  $m$  bits according to a predetermined conversion rule and arranging the  $m$  bits in a lower 1 bit of the multi-level  
10 data of  $m$  symbols, where  $k$  is an integer satisfying  $m > k \geq 1$ , so as to convert a  $(n \times m - k)$ -bit binary data into 1 set of multi-level data made up of  $m$  symbols.

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7. The multi-level data processing apparatus as claimed in claim 6, wherein  $k = 2$ .

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8. The multi-level data processing apparatus as claimed in claim 6, further comprising:

25 means for relating data within other sets to the  $m$

bits when converting the  $(m - k)$ -bit binary data into the  $m$  bits.

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9. The multi-level data processing apparatus as claimed in claim 6, further comprising:

means for mixing to the multi-level data made up of  
10 the  $m$  symbols a test data which includes  $2^{(M \times n)}$   
combinations of  $M$  consecutive multi-level data, where  $M$   
is an integer satisfying  $M \geq 3$ .

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10. The multi-level data processing apparatus as claimed in claim 9, which reproduces multi-level data from a reproduced signal which is reproduced from an  
20 information recording medium which is recorded with a  
mixture of the multi-level data amounting to the  $m$  bits  
and the test data, comprising:

means for inputting the reproduced signal of the  
test data and storing signal values of the multi-level  
25 data;

means for inputting the reproduced signal of the multi-level data which has been converted from the binary data;

5 means for calculating errors between the signal values of the multi-level data and the stored signal values;

means for outputting a multi-level data having a smallest error as a judging candidate of each symbol within one set as a first candidate, and outputting a  
10 multi-level data having a second smallest error as a second candidate;

means for generating a candidate of a multi-level data series of m symbols within one set according to the predetermined conversion rule, using the first and  
15 second candidates for each symbol;

means for calculating errors between the signal value of each symbol and stored signal values corresponding to the candidate multi-level data; and

means for outputting as a reproduced multi-level  
20 data a multi-level data series having a smallest total of the errors amounting to m symbols of one candidate.

11. A multi-level data processing apparatus for converting a binary data into a multi-level data having  $n$  bits per symbol, where  $n$  is an integer satisfying  $n \geq 2$ , comprising:

5 a section to arrange a  $\{(n - 1) \times m\}$ -bit binary data in upper  $(n - 1)$  bits of multi-level data of  $m$  symbols, where  $m$  is an integer satisfying  $m \geq 2$ ; and

a section to convert a  $(m - k)$ -bit binary data into  $m$  bits according to a predetermined conversion rule and  
10 arranging the  $m$  bits in a lower 1 bit of the multi-level data of  $m$  symbols, where  $k$  is an integer satisfying  $m > k \geq 1$ , so as to convert a  $(n \times m - k)$ -bit binary data into 1 set of multi-level data made up of  $m$  symbols.

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12. A multi-level data processing apparatus for converting a binary data into a multi-level data  
20 having  $n$  bits per symbol to be recorded on an information recording medium, where  $n$  is an integer satisfying  $n \geq 2$ , comprising:

a section to arrange a  $\{(n - 1) \times m\}$ -bit binary data in upper  $(n - 1)$  bits of multi-level data of  $m$   
25 symbols, where  $m$  is an integer satisfying  $m \geq 2$ ;

a section to convert a  $(m - k)$ -bit binary data into  $m$  bits according to a predetermined conversion rule and arranging the  $m$  bits in a lower 1 bit of the multi-level data of  $m$  symbols, where  $k$  is an integer satisfying  $m >$   
5  $k \geq 1$ , so as to convert a  $(n \times m - k)$ -bit binary data into 1 set of multi-level data made up of  $m$  symbols; and

a section to mix to the multi-level data made up of the  $m$  symbols a test data which includes  $2^{(M \times n)}$  combinations of  $M$  consecutive multi-level data, where  $M$   
10 is an integer satisfying  $M \geq 3$ , to be recorded on the information recording medium.

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13. The multi-level data processing apparatus as claimed in claim 12, which reproduces multi-level data from a reproduced signal which is reproduced from the information recording medium which is recorded with  
20 the mixture of the multi-level data amounting to the  $m$  bits and the test data, comprising:

a section to input the reproduced signal of the test data and store signal values of the multi-level data;

25 a section to input the reproduced signal of the



multi-level data which has been converted from the  
binary data;

5 a section to calculate errors between the signal  
values of the multi-level data and the stored signal  
values;

a section to output a multi-level data having a  
smallest error as a judging candidate of each symbol  
within one set as a first candidate, and to output a  
multi-level data having a second smallest error as a  
10 second candidate;

a section to generate a candidate of a multi-level  
data series of m symbols within one set according to the  
predetermined conversion rule, using the first and  
second candidates for each symbol;

15 a section to calculate errors between the signal  
value of each symbol and stored signal values  
corresponding to the candidate multi-level data; and

a section to output as a reproduced multi-level  
data a multi-level data series having a smallest total  
20 of the errors amounting to m symbols of one candidate.